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Indian Standard

AUTOMOTIVE VEHICLES — FUEL INJECTORS—HAND LEVER TESTING APPARATUS —SPECIFICATION

ICS 43.060.10

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 1998

Price Group 4

Automotive Primemovers Sectional Committee, TED 2

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Automotive Primemovers Sectional Committee had been approved by the Transport Engineering Division Council.

An assessment of the functional performance of individual fuel injector is a necessary step in testing of fuel injection equipment. A form of hand lever operated testing and/or setting equipment for injectors has been evolved over the years; it has been found in principle effective and adequate to perform the test. Differences in certain physical values between equipment from different manufacturers and of different designs have however resulted in lack of correlation of results.

In the preparation of this standard considerable assistance has been derived from the following:

> ISO 8984-1 'Road vehicles—Testing of fuel injectors for compression ignition engines—Part 1 — Hand lever operated testing and setting apparatus'.
>
> ISO 8984-2 : 1987 'Road vehicles — Testing of fuel injectors for compression ignition engines—Part 2 — Test procedures'.

This standard also specifies minimum requirements for hand lever operated testing and setting apparatus to perform certain tests on fuel injectors for compression-ignition engines. These tests are:

a) Nozzle opening pressure,

b) Spray and repetition, and

c) Seat tightness.

This standard concerns fuel injectors having a spring loaded nozzle valve actuated by fuel pressure. The injector is connected to the apparatus by an adapter specified by the injector manufacturer.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

AUTOMOTIVE VEHICLES — FUEL INJECTORS—HAND LEVER TESTING APPARATUS —SPECIFICATION

1 SCOPE

This standard specifies the requirements of hand lever operated testing and setting apparatus of the injectors of fuel injection equipment for compression ignition engines requiring fuel delivery of up to 300 mm^3 per injection per cylinder at full load.

2 REFERENCES

The following Indian Standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
4218	ISO Metric screw threads
(Part 1) : 1976	Basic and design profiles (*first revision*)
(Part 2) : 1976	Diameter pitch combinations (*first revision*)

3 GENERAL REQUIREMENTS

3.1 The hand tester is valid for use in different locations, such as laboratories, factories or service stations.

3.2 With the hand tester, the test equipment manufacturer shall provide proper organization installation and maintenance instructions in conformity with this standard, including the values specified in **5.3** (a) and (b).

3.3 The fuel injector manufacturer shall state all the tests in the standard along with any additional requirements applicable with instructions for a particular fuel injector or range of fuel injector supplied.

4 TEST CONDITIONS

4.1 The tests shall be carried out with the following test conditions.

4.1.1 *Test Oil*

Any light and chemically inert oil corresponding to calibration fluid as detailed below:

Slightly yellowish oil, free from undissolved liquid and solid impurities.

Mineral oil, additives to improve resistance to ageing and protection against corrosion and wear.

Density at 15°C	0.820 to 0.830 g/ml
Kinematic viscosity at 40°C	2.45 to 2.75 cs
Flash point	75°C, *Min*
Cloud point	– 10°C, *Max*
Aromatic components	Approx 12 percent, *Max*
Normal room temperature	300°K
High pressure pipe of:	
Outside diameter	= 6 mm
Inside diameter	= 2 mm and
Length	= 400 mm with the union nuts of suitable thread to suit the individual injectors

4.1.2 The high pressure pipe used shall be of seamless tube, free from burrs and scales.

4.1.3 The hand tester shall be in good condition which shall be checked and ensured before start of testing.

4.1.4 The details of the injector such as opening pressure, group of the nozzle shall be as per manufacturer's recommendations.

4.2 Fitment and Flushing

Connect the injector to the hand tester through the high pressure pipe of suitable threads of union. Isolate the pressure gauge by closing the valve, then pump several times till spray comes out freely from the nozzle. Care shall be taken such that there are no leakages at the joints.

5 TEST ARRANGEMENT

The testing arrangement shall be as shown in Fig. 1.

The following components are not indicated in the Fig. 1 but they are essential to testing:

a) Blank,
b) Reference pressure gauge, and
c) Volume measuring device.

5.1 The whole mechanism shall be self-contained and of robust construction capable of being rigidly mounted. The filter, test oil container and lid may be separate, if desired.

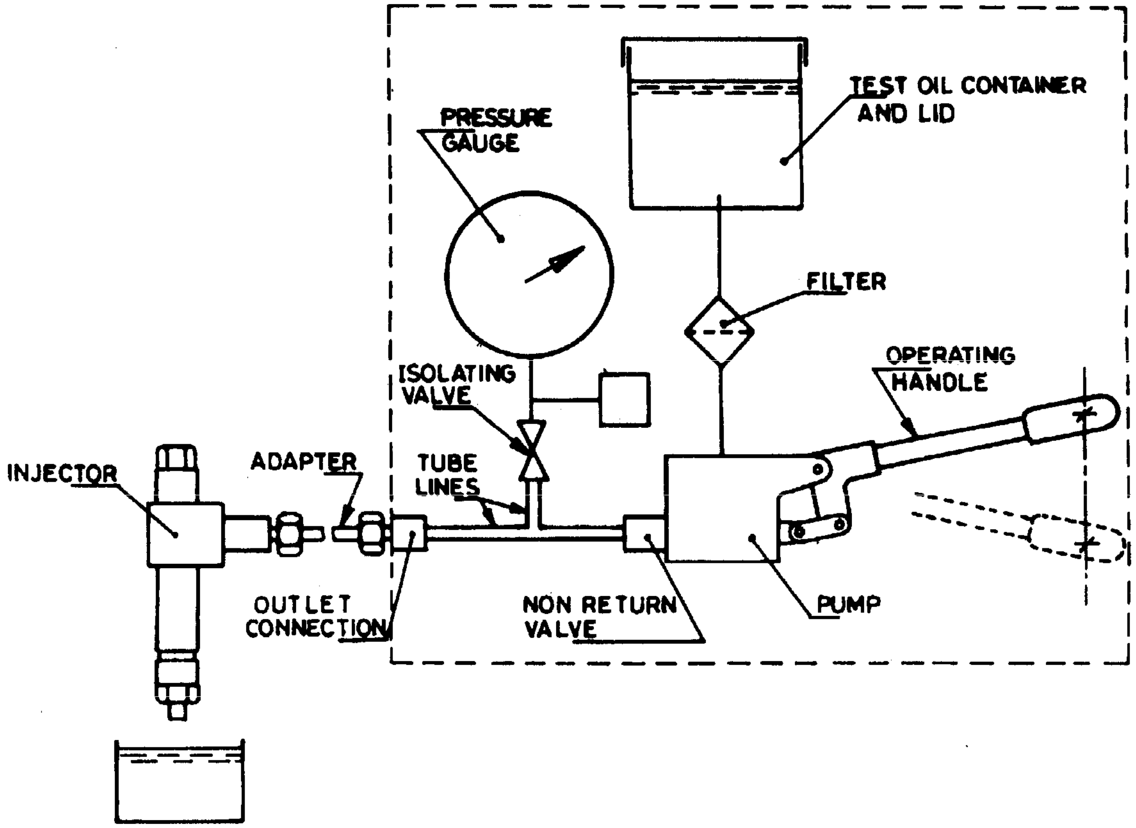

FIG. 1 TYPICAL ARRANGEMENT OF HAND LEVER OPERATED TESTER

5.2 The operating handle shall have a vertical plane of action and the line of action(s) drawn between the positions of the centre point of the hand grip at extremes of stroke shall be approximately vertical.

5.3 The pump shall incorporate a piston and lever system such that the following parameters are achieved:

a) The stroke of the operating handle along the line of action(s) which produces geometric delivery shall be between 125 mm and 325 mm.

b) Specific delivery (at atmospheric conditions) shall be between 4.5 mm^3 and 6.0 mm^3 per millimetre of stroke along the line of action(s).

c) The hydro-mechanical stiffness of the hand tester, with the isolating valve closed and the outlet connection closed off, shall not be less than 0.2 MPa/mm (2.0 bar) measured in the range 5 MPa to 35 MPa (50 bar to 350 bar) and along the line of action (s).

5.4 The element of the pump inlet filter shall be replaceable without risk of any foreign matter entering the pump.

5.5 The fluid container and filter container where applicable shall have a smooth and corrosion resistant internal finish with a sufficiently large opening to give ample access for cleaning. The container lid and breather shall prevent ingress of foreign matter.

5.6 The pump shall discharge through a non-return valve which seals against return flow and has no unloading feature.

5.7 The tube lines connecting the non-return valve to the outlet connection and the isolating valve shall be constructed so that at no point the cross-section is less than 2 mm in diameter.

5.8 A manually operable isolating valve shall prevent communication with pressure gauge. It shall be capable of sealing completely in both directions. The valve spindle seal shall be on the pressure gauge side of the sealing interfaces. Change of internal trapped volume due to valve spindle axial movement need not be zero but shall be kept to a minimum.

5.9 The pressure gauge and external damper if fitted shall be of robust construction with the following requirements:

a) *Range*—0 MPa (normal) to 40^{+2}_{-0} MPa (400^{+2}_{-0} bar)

b) Accuracy in fitted attitude (including hysteresis)—Within 0.6 percent of full scale deflection from 10 percent to 90 percent full scale deflection. The needle shall lie within 1 to 2 mm in front of a flat scale.

c) *Scaling*—Graduation pitch of 0.2 MPa (2 bar) graduation, to commence at approximately 5 percent full scale deflection.

NOTE — Though this specification describes an analogue type Bourdon tube pressure gauge, other methods of pressure measurement are acceptable provided they allow equivalent assessment of the injector.

5.10 The outlet connection shall be a male connector complying with IS 4218 with M 14 × 1.5 thread.

5.11 The adapter shall be specified by the injector manufacturer.

5.12 A reference pressure gauge shall be capable of measuring (with or without reference to a test certificate) to an accuracy of at least 0.2 percent full scale deflection, over range similar to that of the hand tester pressure gauge.

6 TESTS

6.1 The following tests shall be carried out on the fuel injectors:

a) Opening pressure test (*see* **6.2**),
b) Seat tightness test (*see* **6.3**), and
c) Spray and repetition (*see* **6.4**).

6.2 Opening Pressure Test

6.2.1 The test shall be carried out by opening the valve slightly and raising the pressure in the injector by slowly moving the hand lever down.

6.2.2 The pressure raises in the manometer pressure gauge and the pointer moves and at a point it stops further movement and drops a little suddenly due to flow of test oil through throttle nozzle spray hole.

6.2.3 The maximum reading up to which the pointer has moved shall be taken as opening pressure. This test is not intended to judge the quality of spray during this operation.

6.3 Seat Tightness Test

Keep the valve in open position and the nozzle facing downward position, then raise the pressure by moving the hand lever downward until the pointer in the manometer reads 20 bar less than the opening pressure. Hold the pressure for ten seconds. No drop of oil shall separate from the tip of the nozzle. During this test it shall be ensured that nozzle back leak does not reach the nozzle.

6.4 Spray and Repetition

Before carrying out this test close the valve so that a correct judgement of spray and repetition behaviour of the nozzle type shall be known.

7 HOLE TYPE NOZZLE

The hole type nozzles are to be checked as per the following table:

Group	*Repetition*	*Spray Pattern/ Atomisation*
I	Good repetition in the entire range of attainable lever speed: one downward stroke/second	At lower test speeds the atomisation/spray is coarse (homogeneous). At fast lever speeds the spray is compact and finely atomised.
II	Good repetition at slow and fast lever speeds. In between there can be a small non-repeating range.	At lower lever speeds the spray is coarse (non-homogeneous). In the non-repeating range the spray comes out in non-atomised streams. The spray is compact and finely atomised.
III	These nozzles repeat only at slow and very fast lever speed. In between there is a broad non-repeating range.	At slow and intermediate speeds the spray comes out in non-atomised stream and even drops may fall at fast lever speed (4 to 6 strokes/ sec) the spray is compact and finely atomised.

8 PINTLE TYPE NOZZLE

8.1 The pintle type nozzles shall conform to the requirements specified in the following table:

Design and Nozzle Type	*Repetition*	*Spray Pattern/Atomisation*
Pintle type nozzles without throttling (delay) effect	These nozzles repeat audibly over the entire range of attainable lever speed. Lowest speed: one downward stroke/sec.	Well atomised and uniform spray irrespective of the lever speed.
Pintle type nozzles with delay effect	Because of special design features, these nozzles repeat very softly. A repetition test on these nozzles is feasible only between 1 and 2 downward strokes/sec. Repetition ceases when the test speed is increased. The test oil then emerges from the nozzles with a hissing noise at fast lever speed (4 to 6 strokes/sec) the nozzle repeats with a shrill whistle tone.	Until the shrill whistling tone is reached the spray emerges in unatomised streams A divided spray and a flag like side fin formation (non-homogeneous) is of no significance in this range (repeating at throttling stroke overlapping lift). It is possible to judge the spray pattern only at fast lever speed (4 to 6 strokes/sec). At this speed the spray shall be compact and well atomoised (repetition at full lift of needle).
Pintaux type nozzles	Same as for pintle nozzles with delay effect. These nozzles have a special shaped face and an additional spray hole through which the pilot spray emerges.	At low test speed most of the spray (delivery quantity) should emerge from the pilot spray hole well atomised and without much side fin formation. At fast lever speed most of the spray comes out normally through the pintle. The spray from the auxiliary spray may or may not be visible. Ensure that the hole is not clogged by carbon deposits. For new as well as old nozzles, judgement of the main spray is possible only when the speed is accelerated to about 4 to 6 strokes/sec. The spray shall be compact and well atomised (observe spray angle). If the main spray comes out at low test speed, it indicates the gap between pintle and main spray hole has enlarged due to mechanical wear.

9 TESTS ON USED INJECTORS

9.1 The following tests shall be carried out on used injectors:

a) Opening pressure test (*see* **6.2**),

b) Seat tightness test (*see* **6.3**), and

c) Spray and repetition (*see* **6.4**).

NOTE — The spray and repetition test shall be carried out at the frequency of 4 to 6 strokes/sec at the fastest speed on hand tester. While performing the test it shall be ensured that the spray shall be in well atomised condition and the nozzle may or may not repeat with audible sound. If the opening pressure is less, readjust that to a specific value and repeat the test.

10 RECORD OF TEST RESULTS

10.1 A standard record sheet may be used for recording injector condition. Specimen record sheet is given below:

MEASUREMENT RECORD SHEET FOR INJECTOR

Injector Comb. No.______________________________ Opening Pressure—bar
Nozzle Holder_________________________________ Application.
Nozzle______________Test Equipment____________________Oil________
Spray Grading_________________________________
Repetition Grading_____________________________ P = Poor, OK = Okay, G = Good
Seat Tightness Grading_________________________ P = Poor, Soft = Okay, G = Good
T = Tight, U = Untight, Tw = Tipwet

Serial Number	*Manufacturing Date*	*Opening Pressure*	*Spray*			*Repetition*			*Seat Tight*
			S	M	H	S	M	H	

S = Slow M = Medium H = High

11 VALIDATION TEST PROCEDURE

11.1 Preparation

a) Fill the system with a fluid and then flush it. Fit an injector and operate the pump through atleast 10 full strokes after the injector first sprays at its normal opening pressure with the isolating valve open.

b) It is important that any air in the system is expelled or dissolved before commencement of the following validation procedure, for example by maintaining a pressure of 10 MPa (100 bar) for one hour.

NOTE — The spray from an injector can penetrate human skin; to avoid injury keep away from the spray.

11.2 Tightness of Whole System

It shall be checked every month by a blind nozzle holder.

11.2.1 *Element Tightness*

It shall be checked by connecting a blind nozzle holder and building up pressure to 150 kgf/cm^2 (148 bar) by the operating hand lever. Pressure shall increase further when lever is operated slowly approximately one downward stroke in three seconds. In case pressure is not reached replace the element.

11.2.2 *Delivery Valve Tightness*

The test shall be carried out by building up the pressure to 250 kgf/cm^2 (246 bar) and release the lever. The pressure shall not drop within 30 seconds. If there is a drop in pressure, the delivery valve needs to be replaced.

11.2.3 *Three-Way Valve Tightness*

Replace blind nozzle holder with a normal injector. Close the valve (screw in clock wise) pressure gauge shall not register any pressure when the hand lever is operated.

11.2.4 *High Pressure Pipe*

Examine the nipples for any deformation/pressing in. In case any deformation/pressing in is observed then clean the bore with a drill of 2 mm dia. The pipe has to be flushed before use.

11.2.5 *Gauge Integrity Test (Pressure Gauge, with a Master Pressure Gauge)*

Connect the master pressure gauge with a free end of high pressure pipe. Build up the pressure gradually. Compare the pressures registered on master pressure gauges.

11.2.6 *Back Leakage Test*

This test shall be conducted on the hand tester with a variable volume device. Flush injector five times with isolating valve in closed position. Open isolating valve and raise pressure (Pa) to approximately equal to 5 bar less than the opening pressure. Allow the pressure to drop freely from a pressure (Pb) to 25 bar less than the opening pressure. Record pressure (Pc) after a lapse of five seconds. The injector shall be considered to have passed the test if the pressure drop from Pa to Pc is 30 bar approximately. The actual pressure levels, pressure drop and reference temperature shall be supplied by the manufacturer.

12 RECORD OF TEST RESULTS

12.1 Master injectors are supplied with opening pressure set to 120, 150 and 200 kgf/cm^2 (118, 148 and 197 bar), connect the master injectors one by one and compare the opening pressure registered on the nozzle tester pressure gauge. If there is a variation in the nozzle tester pressure gauge, get the pressure gauge repaired or devise a correction chart. Maintain a record card as per the specimen given below and record the observations.

Record Card for
Overchecking of Nozzle Tester

			Card No. Opened on	
Owner	Nozzle tester: Make & Type : Sl No. Purchase Date:		Manometer Make: Type : Other Details :	
Test for	Observed Condition	Action Taken	Observed Condition	Action Taken
Element				
Delivery valve				
Shut-off valve				
High pressure pipe				
Pressure 120 kgf/cm^2				
Gauge 150 kgf/cm^2				
Reading 200 kgf/cm^2				
Overchecked by: Signature:	Date: Next overchecking date:		Date: Next overchecking date	
			Mention Sl. Nos. of master injectors used	

13 MAINTENANCE

13.1 Certain validation tests shall be carried out periodically to ensure functional conformity of the equipment with this standard. In the absence of specific instructions by the hand tester manufacturer, the test details given in Table 1 shall be applied.

Table 1 List of Validation Tests to be Performed on the Hand Tester as Part of A Maintenance Schedule

Test	Interval	Special Apparatus
Preparation of the hand tester (*see* **11.1**)	Prior to all validation test	Injector (any)
Tightness of whole system (*see* **11.2**)	Every 6 months	Blank
Pump plunger (and inlet valve or port) leakage (*see* **11.2.1**)	do	do
Leakage of gauge isolation valve and non-return valve (*see* **11.2.3**)	Every 3 months	Reference pressure gauge
Gauge integrity (*see* **11.2.5**)	do	do

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